

Purkyně's (Purkinje's) Muscle Fibres in the Heart

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".... Finally I may perhaps say that I do not know of a sadder example of the limitations of the human intellect than the history of our knowledge of cardiac motions".

J. E. Purkinje (1844)

Jan Evangelista Purkyně (1787–1869) died 100 years ago. He was mourned by the entire Czech nation in whose cultural renaissance he had played a prominent part, and by many leading European physiologists and histologists who had sat at his feet and had been inspired by him.

The unfamiliar but correct spelling "Purkyně" pronounced "Poorkeynie" must be explained. According to John, Purkyně's main biographer (John, 1959), there are at least nine different spellings of Purkyně's name in world literature. All this started with the unsuccessful attempt by a German priest to make a correct entry of Purkyně's Czech name into the Register of Birth of the little town of Libochovice. Purkyně himself learned the correct spelling of his name only when he entered Prague University and used it from then onwards in his private correspondence. In his publications he used the German version "Purkinje" until 1850 when he returned to Prague as professor of physiology. In this article the spelling is used as it appeared in Purkyně's contributions, and in those by others who referred to his work.

Purkyně's catholic interests and original observations are well known. His *annus mirabilis* was 1832 when—after a seven years' war with the university authorities in Breslau—he was given a Ploessel microscope with an achromatic lens. Soon afterwards his assistant Adolf Oschatz (1812–1857) presented him with a new microtome (1842) which was far superior to the various modifications of the model described by John Hill (1717–1775) in 1770.

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Jan Evangelista Purkyně

Purkyně himself added some new methods of fixing and staining, a micrometric compressorium, and even produced some photomicrographs in those early days of daguerrography. All this started a flood of histological investigations by Purkyně and his pupils at Breslau who left few organs of the human body unexplored. His successor in Breslau, Richard Heidenhain (1834–1897), rightly called Purkyně “the father of our knowledge of the living microscopic structure of living bodies”.

Purkyně's fame rests today mostly on his description of nerve and cerebral structures, and of the subendocardial fibres which carry his name. On the occasion of the centenary of his death a few little known aspects of the detection and belated appreciation of the function of Purkyně's muscle fibres may perhaps be recorded.

Many historians of cardiology (Burch and De Pasquale, 1964; Fishman and Richards, 1964; Willius and Dry, 1948) state that it was not Purkyně himself but his pupil Boguslaus Palicki (1813–1868) who first described the subendocardial fibres, in his Doctor's thesis in 1839. We carefully studied the Latin text of Palicki's thesis and its translation into Czech and failed to find any mention of the specific subendocardial structures. It was Purkyně himself who described them in 1845 in the widely read “*Archiv für Anatomie, Physiologie und Wissenschaftliche Medizin*” edited by the German physiologist Johannes Müller (1801–1858). Strangely enough—in view of what Purkyně believed to be the function of the subendocardial fibres—the article is headed “*Microscopic-Neurological Observations*”.

Purkyně started by saying that he first observed the “network of greyish flat threads in the heart of sheep”, that they continued partly into the papillary muscles and around other thread-like bundles, partly like bridges across single folds and clefts of the ventricular walls. He observed them first with the naked eye (“mit dem freien Auge”), and saw them later under the microscope as densely packed grains (“Koerner”) presenting a polyhedral appearance. From Purkyně's work in the field of cellular histology and physiology it is quite clear that by grains he meant cells (Purkinje, 1838).

He emphasized that these newly observed threads had no relation to nerve fibres, and he was inclined to believe that they were similar to “cartilaginous tissue”. He pondered about the functional significance of these “relatively soft tissues” embedded into the “enormous” muscular masses of the heart. He finally settled for the hypothesis that the fibres belonged to the “apparatus of motion” and that their cell membranes were muscular structures. He added that he had found similar structures in

the hearts of cattle, pigs, and horses but that he had failed to identify them in dogs, hares, rabbits, and man.

Purkyně reported again on these fibres at a meeting of the “Silesian Society for Patriotic Culture” in 1846 (published in 1847). His paper was reported in only 9 lines, but it seems that he had formed more definite, though not more enlightened, views about the function of his fibres: “They are not a new specific tissue but belong to the group of muscular fibres. They are extremely shortened and multiplied. By being arranged in rosary-like formations they can concentrate their action on individual points and by simultaneous action they can stiffen the surface of the cardiac cavities”.

Thus he considered their functional significance as purely mechanical.

Nine years later and after Purkyně had achieved his life's greatest ambition and had become professor of physiology at Prague, he demonstrated the subendocardial fibres to the Royal Bohemian Scientific Society (Purkyně, 1853). He had little new to add except that he believed he had found the fibres in the hearts of the goose, the goat, the deer, and the camel. He still had not identified them in man. He still believed that their function was the stiffening of the interior ventricular walls.

During the next 60 years Purkyně's subendocardial fibres were a matter of interest mostly to morphologists who discovered the specialized conductive system of the heart in “the reverse order in which they are normally activated during the cardiac cycle” (Stock, 1969). The new structures became known as “Purkyně's fibres” as the result of Kölliker's (1817–1905) widely read textbook. Kölliker also believed in their purely mechanical function (Kölliker, 1852). Aebly (1835–1884), professor of anatomy in Basle, believed them to be “developmental forms” of cardiac muscular fibres (Aebly, 1863).

The German anatomist Obermeier (1843–1873) found Purkyně's fibres in a large number of vertebrates but failed to detect them in human hearts (Obermeier, 1867). In France the histologist Ranvier (1835–1922) thought that the subendocardial structures were muscular fibres which had remained in an embryonic state (Ranvier, 1875). In 1877 the German anatomist Gegenbaur (1826–1903) saw Purkyně's fibres in the heart of adult man.

The German veterinary surgeon Reinhold Schmaltz (1860–1945) seems to have made the first inspired guess as to the function of the subendocardial fibres. He suggested in 1886 that they were the terminal apparatus (Endapparat) of the cardiac musculo-motor system. Three years earlier, Walter Holbrook Gaskell (1847–1914) described an atrio-

ventricular "bridge" in the heart of the tortoise, and suggested that the carriers of cardiac impulses were muscular structures which differed from other cardiac fibres. He declared that "these experiments showed definitely that the ventricle contracts after the auricle only when a contraction wave passes through the auriculo-ventricular groove" (Gaskell, 1883). Thus he started to demolish the concept of a rigid, impenetrable atrioventricular barrier in which at that time, and for many years to come, many leading physiologists believed. It is well known that Gaskell introduced the concept of three degrees of heart block, but it is less well known that in a footnote in his classic paper he gave the credit for first using the term "block" to the zoologist Romanes (1848-1894) (Romanes, 1876).

Gaskell's work opened the way for Wilhelm His, Jr. (1863-1934), professor of medicine at Leipzig, where Gaskell had spent a profitable year in Ludwig's (1816-1895) famous institute in 1874. His wrote in 1893:

"After extensive investigations I was able to find a muscle bundle which connects the auricular and ventricular septal walls, and which apparently had not been observed before, because it is only visible in its entire distribution when the septal walls are cut exactly in a horizontal direction. . . ."

Also in 1893 A. F. Stanley Kent published his paper on "Researches on the Structure and Function of the Mammalian Heart". He concluded:

"... for whereas in the past it has been supposed that the mammalian heart differed from the heart of cold-blooded animals in having a complete break of muscular continuity between auricles and ventricles, it has now been shown that no such break exists but that the auricles are connected with the ventricles both by strands of altered muscular tissue, and by a more complex system of branching and anastomosing fibres which penetrate the fibrous tissue between the two chambers."

Neither His nor Kent mentioned Purkyně's fibres in their papers. The controversy between the protagonists of the myogenic hypothesis of the heart beat, led by Gaskell in England and T. Engelmann (1843-1910) on the Continent, and the believers in the neurogenic origin, continued until the beginning of this century when further morphological discoveries put an end to the dispute. In 1906 Sunao Tawara (1872-1952) published "The Conductive System of the Mammalian Heart; about the Atrioventricular Bundle and Purkinje's Fibres".

He described the discovery of what has become known as the Tawara-Aschoff atrioventricular node and he paid considerable attention to Purkyně's fibres. After commenting on the limited knowledge of their function in the past, and after confirming Gegenbauer's discovery of their presence in the human heart, Tawara wrote:

"I am now, I believe, in a position to offer certain explanations of the hitherto unknown function of Purkinje's fibres on the basis of topographical-anatomical and histological findings. My hypothesis is based on the fact that Purkinje's fibres are nothing else than the terminal extension of the muscular connection between atrium and ventricle, a system which is still incompletely known. It is however, reasonable to assume that these fibres serve the same purpose as the atrioventricular bundle."

As is well known, the last missing link and the primary pacemaker of the heart beat was discovered by Keith (1866-1955) and Flack (1882-1931) in 1907. In their paper they leave no doubt that "the fibres belonging to the Purkinje system are the endorborisations of the conductive system".

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